REMARKS

The Office Action of May 14, 2009, has been received and reviewed. Claims 1 and 3-31 were previously pending and under consideration in the above-referenced application. Each of claims 1 and 3-31 has been rejected. Claims 3-6 and 8 have been canceled without prejudice or disclaimer. New claims 32-35 have been added. Reconsideration of the above-referenced application is respectfully requested.

Rejections under 35 U.S.C. § 102

Claims 1 and 3-31 have been rejected under 35 U.S.C. § 102(b) for being drawn to subject matter that is allegedly anticipated by the subject matter described by U.S. Patent 5,720,845 to Liu (hereinafter "Liu").

A claim is anticipated only if each and every element, as set forth in the claim, is found, either expressly or inherently described, in a single reference which qualifies as prior art under 35 U.S.C. § 102. *Verdegaal Brothers v. Union Oil Co. of California*, 2 USPQ2d 1051, 1053 (Fed. Cir. 1987). That single reference must show the identical invention *in as complete detail* and *in the same arrangement as that contained in the claim. Net MoneyIn, Inc. v. Verisign,* 545 F.3d 1359, 1369-70 (Fed. Cir. 2008) (emphasis supplied); *Richardson v. Suzuki Motor Co.*, 9 USPQ2d 1913, 1920 (Fed. Cir. 1989).

Liu describes a wafer polisher with a polishing head 13 that is configured to hold a wafer 12 and that includes a plurality of discrete actuators 23 that are configured to individually apply different amounts of pressure to different locations on the back side of the semiconductor wafer 12.

The Office has asserted that the discrete actuators 23 of Liu may be magnetically biased. Office Action of May 14, 2009, page 2. Instead of being magnetically biased, Liu mentions that the discrete actuators 23 may comprise magnetostrictive elements. As those of skill in the art are aware, a magnetostrictive element comprises a piston formed from a material that changes shape when exposed to a magnetic field. *See, e.g.,* Ashley, S., "Magnetostrictive actuators," http://www.memagazine.org/backissues/membersonly/june98/features/magnet/magnet.html, (American Society of Mechanical Engineers, accessed August 13, 2009), a copy of which is

submitted herewith for the sake of convenience. The piston is disposed within a cylinder that is surrounded by a coil. *Id.* As a magnetic field is pulsed through the coil, the shape of the piston intermittently changes in a way that causes the piston to mechanically crawl through the cylinder. *Id.* Liu does not provide any express or inherent description of a discrete actuator 23 or of any pressurization structure that is magnetically repelled toward or attracted against a wafer 12 or any other semiconductor substrate.

Independent claim 1, as amended, is drawn to a method in which pressurization structures are magnetically biased by magnetically repelling a pressurization structure or magnetically attracting a pressurization structure. As magnetostriction does not involve magnetic repulsion or magnetic attraction, but, rather, a change in the physical shape of a structure made from a certain material as that material is exposed to a magnetic field, Liu does not anticipate each and every element of amended independent claim 1. Accordingly, it is respectfully submitted that, under 35 U.S.C. § 102(b), amended independent claim 1 is allowable over the subject matter described by Liu.

Claims 3-6 and 8 have been canceled without prejudice or disclaimer.

Claims 9-15 are each allowable, among other reasons, for depending directly or indirectly from independent claim 1, which is allowable.

Claim 13 is additionally allowable because Liu does not expressly or inherently describe a method in which at least one raised area on an active surface of a first semiconductor device structure is located, then *another,* second semiconductor device structure of the same type is polished as pressure is applied to a corresponding area on the back side of the second semiconductor device. Instead, the description of Liu is limited to a technique in which various parameters are monitored as a semiconductor device is polished to enhance the planarity of a polished surface of *that* (*i.e.,* the same) semiconductor device.

It has also been asserted that the discrete actuators 23 of Liu may be biased under negative pressure. Office Action of May 14, 2009, page 2. While Liu discloses that a vacuum may be generated to secure a wafer 12 to the wafer carrier 13, Liu does not expressly or

inherently describe that a vacuum or any other type of negative pressure may be applied to a discrete actuator to affect the amount of pressure a discrete actuator 23 applies to a wafer 12.

Claim 7 has been amended to independent form to include the limitations of the previous version of independent claim 1. As amended, claim 7 is drawn to a method in which a negative pressure is applied to at least one pressurization structure to affect the manner in which the at least one pressurization structure is biased against a substrate. As Liu provides no express or inherent description that a vacuum or any other negative pressure may be applied to a discrete actuator 23 or any pressurization structure, it is respectfully submitted that Liu does not anticipate the subject matter recited by amended independent claim 7. Therefore, under 35 U.S.C. § 102(b), the subject matter recited by amended independent claim 7 is allowable over the subject matter described by Liu.

Independent claim 16 recites a method for polishing at least one layer on a semiconductor device structure. The method of independent claim 16 includes polishing a first semiconductor device structure and locating any raised areas on the polished surface of the first semiconductor device structure. Pressure is then applied to areas on the back side of a second semiconductor device structure that correspond to the raised areas on the polished surface of the first semiconductor device structure, and at least one layer of the second semiconductor device structure is polished.

In contrast to the method of independent claim 16, the description of Liu is limited to monitoring a semiconductor device structure during polishing and, based upon the monitored data, adjusting the amounts of pressure that are applied to different areas on the back side of that semiconductor device (*i.e.,* with in-polishing feedback). Liu does not expressly or inherently describe that pressure may be applied to a back side of a second semiconductor device structure based on an analysis of raised areas on the polished surface of a previously polished semiconductor device structure of the same type (*i.e.,* without the requirement of in-polishing feedback). It is, therefore, respectfully submitted that Liu does not anticipate each and every element of independent claim 16, as would be required to maintain the 35 U.S.C. § 102(b) rejection of independent claim 16.

Each of claims 17-31 is allowable, among other reasons, for depending from independent claim 17, which is allowable.

Claim 17 is further allowable since Liu provides no express or inherent description of a process in which metrology techniques are employed. Rather, the description of Liu is limited to a technique in which friction is monitored.

Claim 27 is additionally allowable since Liu does not expressly or inherently describe using a magnet to repel at least one pressurization structure toward the back side of a semiconductor device structure.

Claim 28 is also allowable because Liu neither expressly nor inherently describes using a magnet to attract at least one pressurization structure toward the back side of a semiconductor device structure.

Claim 30 is additionally allowable since Liu lacks any express or inherent description of a process in which a negative pressure is applied to at least one pressurization structure.

In view of the foregoing, withdrawal of the 35 U.S.C. § 102(b) rejections of claims 1 and 3-31 is respectfully solicited, as is the allowance of each of claims 1, 7, and 9-31.

New Claims

New claims 32-35 have been added. New claims 32-35 depend from amended claim 7. It is respectfully submitted that none of new claims 32-35 introduces new matter into the above-referenced application.

CONCLUSION

It is respectfully submitted that each of claims 1, 7, and 9-35 is allowable. An early notice of the allowability of each of these claims is respectfully solicited, as is an indication that the above-referenced application has been passed for issuance. If any issues preventing allowance of the above-referenced application remain which might be resolved by way of a telephone conference, the Office is kindly invited to contact the undersigned attorney.

Respectfully submitted,

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feature article

Magnetostrictive actuators

Materials that change their shapes when exposed to magnetic fields can now be used to drive high-reliability linear motors and actuators.

By Steven Ashley, Associate Editor

When you place a piece of Terfenol-D near a magnet, the special rare-earth-iron material will change shape slightly. This rather remarkable phenomenon, which physicists call the magnetostriction effect, has been the focus of efforts by engineers at ETREMA Products Inc. in Ames, Iowa, to devise simple, high-reliability linear-motor-based actuators.

The design of these devices is straightforward. The idea is to squeeze a rod of Terfenol-D into a metal tube whose bore size is just slightly smaller than the rod's diameter, wrap a series of electromagnetic induction coils around the tube (or stator), and use the coils to generate a moving magnetic field that courses wavelike down the successive windings along the stator tube. As the traveling magnetic field causes each succeeding cross section of Terfenol-D to elongate, then contract when the field is removed, the rod will actually "crawl" down the stator tube like a worm. Repeated propagating waves of magnetic flux will translate the rod down the tube's length, producing a useful stroke and force output. The amount of motion generated by the material is proportional to the magnetic field provided by the coil system, which is a function of the electrical current. This type of motive device, which features a single moving part, is called an elastic-wave or peristaltic linear motor.

Actuators using innovative linear motors of this type are being developed as part of the U.S. Defense Department's Smart Wing Program. The program is an effort to use smart materials to adjust or fine-tune the shape of the airfoil cross section of an aircraft wing in flight, reduce aerodynamic drag, boost payload capacity, cut fuel use, and improve maneuverability. The development of these compact, low-voltage motors will offer advantages in applications in which high-force, extended-stroke, high-precision, and fail-safe-operating characteristics are required, according to G. Nick Weisensel, chief engineer at ETREMA. Other military uses might include the

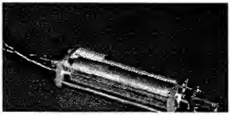
positioning of trim tabs on aircraft, helicopters, and submarines as well as the operation of cargo latches. Civilian applications could extend over a range of industries including paper production, medical dispensing (the controlled delivery of fluids), automotive accessories such as sunroofs, and automotive brake systems. All applications should benefit from higher efficiency, reduced maintenance, and safer solutions, Weisensel said.

Terfenol-D is an example of a smart material, a substance that changes shape when it is subjected to a specific type of energy input. Piezoelectric ceramics such as lead zirconate titanate respond to electricity, shape-memory alloys like nitinol react to heat, while magnetostrictive materials are altered by magnetic fields. As materials researchers have focused on improving the performance of the different families of smart materials during the past few years, engineers have been developing ways to use them in practical devices such as solid-state induced-strain actuators.

Magnetostriction Fundamentals

As noted, magnetostriction is the process by which a ferromagnetic material transforms from one shape to another in the presence of a magnetic field. The discovery of the magnetostriction effect is generally attributed to 19th century English physicist James Joule. This solid-state phenomenon is a result of the rotation of small magnetic domains, causing internal strains in the material. These strains result in a positive expansion of the material in the direction of the magnetic field. As the field is increased, more domains rotate and become aligned until magnetic saturation is achieved. If the field is reversed, the direction of the domains is also reversed but the strains still result in a position expansion in the field direction. Since the magnetostrictive forces are molecular in origin, the mechanical response is very fast—a matter of microseconds.

On the macroscopic scale, a magnetostrictive material conserves volume (of an essentially incompressible material); the diameter decreases as the length grows. The effect generates elastic forces in accordance with a generalized Hooke's law.



This high-reliability actuator uses an induction coil to energize a peristaltic linear motor based on ETREMA's Terfenol-

D smart material.

Terfenol-D, a near-single crystal of the lanthanide elements terbium and dysprosium plus iron, exhibits the greatest magnetostrictive effects of any commercially available material. It is the best example of a giant magnetostrictive alloy, a family of materials that were first discovered in the 1970s by a research group led by A. E. Clark at the Naval Surface Warfare Center in Silver Spring, Md. The research was part of an effort to develop a replacement for piezoceramic transducer technology, which is used in high-performance sonar transducers. The name Terfenol-D is derived from terbium; Fe, the chemical symbol for iron; the Naval Ordnance Laboratory; and dysprosium.

During manufacture, Terfenol-D is melted, cast, and directionally solidified to provide the crystalline microstructure required to produce large strains. The strain and actuation force available from Terfenol-D are superior to those of other smart shape-change materials. "Terfenol-D produces five to 10 times more strain than piezoceramics," Weisensel said. Among smart materials, "it also has the highest energy density: the ability to transform energy inputs into useful energy outputs with few losses." With available strains of more than 1,000 parts per million, the substance generates more force and a larger stroke distance than can be achieved with piezoceramic materials of the same size and shape. "For example," Weisensel said, "we're developing an advanced sonar for the U.S. Navy that has Terfenol-based projectors [transducers] that are one-third the size and weight of current systems but produce a higher sound output."

Terfenol-D also offers a broad range of operating temperatures (—60°F to 160°F), which has benefits in vehicle applications. Another advantage is the fact that the continuous cycling of Terfenol-D through its temperature range has no effect on its magnetostrictive performance, even if its Curie temperature is exceeded. ETREMA spokesmen claimed this is a significant design advantage over piezoceramics, which experience irreversible losses at only 50 percent of their Curie temperature and fully depolarize if the Curie temperature is exceeded.

A key limiting factor for increased use is relatively high cost, which is determined predominantly by the cost of rare-earth materials. "Terfenol-D costs have come down 80 percent in the last three or four years," said Weisensel, who admitted that "high costs scared off a lot of potential

users in the late 1980s." He added that increased manufacturing volume, the automation of the fabrication process, and pressure on rare-earth suppliers have led ETREMA management "to expect similar cost reductions over the next couple of years."

ETREMA researchers, Weisensel noted, are looking to improve Terfenol-D using material characterization methods, schemes to enhance the available strain, and better magnetomechanical design techniques. They also want to make further cuts in costs via manufacturing-process refinements.

"Large-displacement, long-stroke devices have been designed using various amplification schemes based on the accumulation of tiny micropositioning steps," he said. "Usually long stroke and precision positioning are mutually exclusive." Displacement amplification is necessary because solid-state induced-strain actuators generate relatively small displacements compared with standard hydraulic actuators, for example.

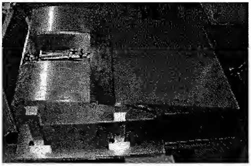
Various types of hydraulic amplifiers other than no-backlash linear motors have been developed. A good example is ETREMA's Vulkan series of integrated electric actuators. The operation of the Vulkan actuator is simple: A piece of coil-excited Terfenol-D drives a bidirectional positive-displacement pump to move and pressurize a hydraulic fluid and active flow-control valves. The flow-control valves are commanded by phased signals that precisely open and close the inlet and outlet of the pump. Displacement amplification is provided by a "ram-within-a-cylinder" concept. The design combines the pump, valves, and controller in one sealed package, which means the devices can serve as self-contained hydraulic actuators on next-generation electric airplanes with distributed control systems, replacing conventional centralized hydraulic systems. "Instead of hydraulic lines, you run a wire to it," Weisensel said.

Smarter Wings

The Smart Wing Program embodies an entire range of approaches to deforming wing-control surfaces to improve performance, according to Jayanth Kudva, manager of the Advanced Structural Concepts Department at Northrop Grumman Corp.'s Military Aircraft Systems Division in Hawthorne, Calif.; the program's prime contractor. Funded by the Defense Advanced Research Projects Agency (DARPA) in Arlington, Va., the program is being managed by the Air

Vehicles Directorate of the U.S. Air Force Research Laboratories at Wright-Patterson Air Force Base in Dayton, Ohio, in cooperation with NASA's Langley Research Center in Hampton, Va. The center is providing access to its wind-tunnel test facilities. The program's chief subcontractor is Lockheed Martin-Denver.

Engineers use this laboratory testing device to evaluate the application of magnetostrictive linear actuators to a shape-adaptive wing-flap mechanism that could cut drag during transonic flight.



Mark A. Hopkins, smart-structures core-area leader at the Air Force Research Laboratories, noted that the $3.1 million phase 1 of the Smart Wing Program started in February 1995 and will end in June. Phase 2, which began last August and will run to 2001, is receiving $7.8 million in DARPA funding. The program's third phase is aimed "at developing an aircraft design capability that incorporates innovative smart concepts for future airframes, and illustrates the capability in a demonstration of a multidisciplinary designed Smart Air Vehicle," according to DARPA documentation.

The current Smart Wing Program, Kudva added, is the result of the merging of two separate DARPA research programs involving the use of smart materials to alter the shape of aerodynamic control surfaces. The combination of programs came about in large measure following the corporate merger of Northrop and Grumman Corp. a few years ago. The non-ETREMA-related project, he said, is concerned with improving the maneuver control (roll rate and so forth) of fighter aircraft. "When a conventional control surface is deployed, the hinge produces a sharp slope discontinuity that produces drag. We'd like to contour the wing shape like a bird does."

Transonic Cruise Improvement

The idea behind the program is to improve transonic cruise operations, according to Fred Austin, a consultant to Northrop Grumman. "A wing profile is usually designed for a single flight regime [defined by speed, aircraft weight, and so forth]. If you fly off the design condition, the wing shape is not going to be optimal."

The specific goal of the ETREMA-related work is to develop a method to optimize wing shape for minimum drag during transonic cruise. Fuel savings of 3 to 6 percent have been projected and validated by testing, but real-world benefits have been limited due to the use of pivoted tabs that cause abrupt curvature changes. Transonic cruise, Austin said, causes a condition where a portion of the airflow is supersonic, creating a shock wave on the top of conventional control surfaces. "As the air speeds up, it creates a lot of drag. We want to remove or reduce the strength of the shock wave, smoothing the flow on the upper surface, thus cutting drag, which would allow an airplane to fly farther or the same distance with less fuel."

In the Terfenol-D-actuated device, an advanced-design wing flap incorporates multiple deployment segments that would smooth the airflow over the upper surface. Kudva described the new segmented multiflap structure as "like a two-segment Fowler flap." The upper airfoil control surface will have the smooth shape needed to reduce the shock strength with boundary-layer separation. "You're not just rotating a flap about an angle as in a standard control surface," Austin said, "you're rotating and translating it at the same time."

Phase 1 of ETREMA's portion of the program, completed last year, resulted in the demonstration of a 10- to 20-watt linear motor capable of providing a consistent force of 30 pounds over an extended stroke of 1.5 inches with micron resolution. Weighing less than 2 pounds, the unit fits in an envelope about 9 inches long by 1.5 inches in diameter.

In the elastic-wave linear motor, the Terfenol-D rod is enclosed with an interference fit in a stator tube which is enclosed in a series of concentric coils that generate the magnetic field when power is applied. The activation pattern of these fields is controlled by a digital controller, which enables the rod to move inside the stator tube. During this motion, the rod can push and pull loads. When power is turned off, this device will lock itself in the stator tube without any slippage because of the existing contact pressure.

Last March, ETREMA was awarded a $470,000 phase 2 contract by Northrop Grumman. In phase 2, company researchers will concentrate on improvement in travel speed, maximum actuation forces, controller development, and fabrication of second-generation motors that will be used in wind-tunnel testing of the smart wing. "These improvements should result from

better magnetic circuit design, increased operating frequency, and thermal management efforts.

"We're talking with ANSYS [in Canonsburg, Pa.] about adding the modeling capabilities we need to do this kind of interdisciplinary research. Right now, we're awaiting Northrop Grumman's aerodynamic analysis," Weisensel said. The final smart wing demonstration unit will feature a three-dimensional Terfenol-D-powered smart trailing edge.